Exercise Capacity in Patients with Chronic Obstructive Pulmonary Disease

The measurement of peak oxygen consumption at incremental exercise can contribute to disability evaluation, preoperative assessment, diagnosis of exercise intolerance by algorithm, and other clinical decisions. The inherent requirement for patient effort, however, necessitates some caution in applying peak exercise data. Inadvertent acceptance of a submaximal effort as maximal could cause withholding of indicated surgery, for example. A safeguard against this, particularly in COPD patients, would be welcome.

Regression equations describing peak aerobic capacity in patients with COPD may have utility in this context. Equations which reconcile measured peak oxygen consumption with measured pulmonary defects could increase the likelihood of correct clinical actions based on exercise testing. Consistency between observed and predicted values implies that all relevant factors have been taken into account. Depending on the predictor variables chosen, some regression equations assess the technical credibility of measurements rather than clinical consistency.

A report by Carlson and colleagues in the current issue (see page 307) presents a multivariate description of peak oxygen consumption in one group of COPD patients (n=54) with application of predictions to another group (n=56). The patients performed treadmill exercise in the bronchodilated state. The sample size, as well as some of the specific findings, justify careful consideration of this report.

Carlson and colleagues identified the 12 second maximum voluntary ventilation (12s MVV) as a determinant of peak oxygen consumption. The findings agree with earlier work by Armstrong and colleagues who also used MVV in multivariate analysis to describe peak oxygen consumption in COPD patients. Several studies have shown the importance of ventilation in limiting exercise in COPD.

In recent years, MVV has made a comeback in popularity as a test of pulmonary function. This trend has arisen in part from the popularity of exercise testing with the attendant need for a reliable estimate of breathing reserves (BR) and the confirmation of ventilatory limitation of exercise (VLE).

By finding MVV to be a determinant of peak oxygen consumption, the data of Carlson and colleagues add further support to the call of others for measurement of 12s MVV in association with exercise testing. Use of the FEV₁ as the sole basis to predict maximum exercise ventilation should be avoided.

The MVV test itself depends on multiple variables which also influence exercise ventilation. Earlier reports showed forced expiratory volume in one second (FEV₁), maximum inspiratory flow rate (MIFR), and peak inspiratory pressure (PIP) to be determinants of exercise performance in COPD patients with VLE. The MVV in the Carlson study may be seen as aggregating these determinants into one variable.

The report by Carlson and colleagues did not subdivide individual responses with respect to ventilatory, cardiac or effort limitation of exercise. Their approach has the advantage of including all patients. On the other hand, it seems intuitive that difficulties could arise when attempting to predict maximum exercise capacity from respiratory variables in patients who do not manifest VLE. My own preference would be to use MVV to confirm VLE in individual patients and to use other resting variables to predict peak oxygen consumption in patients with VLE.

Carlson and colleagues also identified Vd/Vt at peak exercise (with a negative sign) as a predictor of peak oxygen consumption in COPD. Their methods used arterial Pco₂, not end-tidal Pco₂, to determine Vd/Vt. That Vd/Vt subtracts from peak oxygen consumption in COPD seems entirely plausible; however, use of peak exercise Vd/Vt as a predictor variable has additional implications.

The Vd/Vt usually decreases with exercise even in patients with COPD, as found in both groups A and B of the Carlson study. If, for example, a patient voluntarily stopped exercising 2 minutes prematurely, the Vd/Vt term in the equation can lower the prediction by subtracting more than would be subtracted with decline in Vd/Vt on further exercise. This can bias the prediction toward agreement with observed values in cases of submaximal effort. Inclusion of most peak exercise variables as predictors of peak oxygen consumption would behave similarly. This “self-correction” is useful for assessing technical consistency, but may confound interpretation of clinical consistency.

For several reasons, the estimates from the equation of Carlson may be lower than observed if applied to yet another sample. The oxygen consumption in group A (1.25 L/min), for example, seems low for the FEV₁ (1.43 L) compared to earlier studies as do diffusing capacity (D) and MVV (mean MVV/mean FEV₁/35).
The effects of the patient's sex, increment protocol, patient effort and other factors may all have lowered peak oxygen consumption in this study relative to others. This illustrates the present difficulty of transferring a formula from one lab to another. For the foreseeable future it may be that only the variables, and not the coefficients, may be readily transported.

The authors raised a concern that their equations may lack sufficient accuracy to be useful for individual predictions. This may imply a need to refine the target population, as discussed above, or to search for other predictor variables, or both. Their concerns do not necessarily apply to other studies done with other methods. Also, examination of individual values as a percentage of predicted, a common practice in pulmonary function testing, conceivably could modify impressions about accuracy.

Regression equations will rarely if ever substitute for actual exercise testing, but a need remains for an accurate estimate of exercise capacity in patients with COPD. The report by Carlson and colleagues has both broken new ground and strengthened earlier findings. Hopefully, future work will further refine the predictions so we can more confidently apply these clinical measurements for the benefit of our patients.

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### References


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### Cardiopulmonary Bypass and Coronary Artery Bypass Graft

**Are the Risks Necessary?**

The surgical treatment of coronary artery disease is constantly undergoing alteration and refinement in order to meet the changing clinical challenges brought on by an aging population, recurrent disease, and attempts at relatively nonsurgical revascularization. The report presented in this issue (see page 312) demonstrates how old and abandoned methods are sometimes useful to meet modern challenges.

The series of 700 patients undergoing coronary revascularization without the use of cardiopulmonary support reported by Benetti et al is an impressive demonstration of technical ability. Their results for all age groups are exemplary. We, too, have felt that in certain groups, the major risk factor of surgical revascularization was related to extracorporeal circulation (ECC). We began doing bypass grafts without ECC in certain high-risk groups who could either be completely or adequately revascularized through the LAD and RCA systems. From January 1, 1987 to September 30, 1990, we operated on 203 patients without cardiopulmonary support. Most of the patients had renal insufficiency, diseased ascending aorta, inoperable cerebral vascular disease or were Jehovah’s Witnesses with decreased RBC mass. Many were re-do patients with one or more of these risk factors. After demonstrating our capability to perform the operation successfully, we operated on several low risk patients who could be considered ideal candidates for percutaneous transluminal angioplasty (PTCA). The feeling was that mammary artery grafting off bypass would give the patient revascularization with a far superior longevity than percutaneous transluminal angioplasty (PTCA) and that was at a more comparable early cost which may be more cost-effective than percutaneous transluminal angioplasty in the long run.

Of the 203 patients undergoing surgery during this time, 77 percent had internal mammary artery grafts and 65 percent were completely revascularized with IMAs. Thirty-day mortality was 1 percent, and two-year follow-up showed 0.5 percent mortality. In comparing this group with a matched group of 215 patients in whom cardiopulmonary bypass was needed because of either technical or hemodynamic instability reasons, we found significantly better results in the off bypass group:

<table>
<thead>
<tr>
<th>Off Bypass</th>
<th>On Bypass</th>
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<tbody>
<tr>
<td>Mortality</td>
<td>1.0</td>
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<tr>
<td>CVA</td>
<td>0.5</td>
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<tr>
<td>No transfusion</td>
<td>81%</td>
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<td>Mean postop stay</td>
<td>8 days</td>
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We, too, felt that in certain groups of patients,